Uncovering Policy Makers' Loss Function

Paolo Surico*
Bocconi University

September 2002

Abstract

The quadratic form of policy makers' loss function has gained a wide consensus in monetary policy analysis mainly because of its analytical tractability. A number of researchers, however, have recently proposed alternative functional forms which have also proved to yield tractable solutions of the central bank optimization problem. Using a nonparametric specification of the output gap argument into the loss function, this paper attempts to discriminate among three classes of proposals through the evidence drawn upon the form of the US efficient policy frontier.

JEL Classification: C52, E52.

Keywords: nonquadratic loss function, efficient policy frontier, kernel regression

*I wish to thank Barbara Chizzolini for useful comments. Address for correspondence: Istituto di Economia Politica, Università Bocconi, Via Gobbi 5, 20136 Milan, Italy. E-mail: paolo.surico@uni-bocconi.it

1 Introduction

The standard method of model building in the optimal monetary policy literature is to design policy interventions as the solution of a well-behaved control problem in which the central bank moves policy rates to minimize some quadratic objective function. The latter defines the ultimate goals of monetary policy and translates the behavior of the target variables into some measure for policy evaluations. When assigned with such a problem, the central bank faces the constraints representing the structure of the economy. The quadratic characteristic of the objective and the linear feature of the constraints give rise to a linear first order condition which describes the efficient policy frontier that policy makers face.

Such a modeling choice however has been questioned by several practitioners at the policy committees of various central banks on the ground that it has little justification beyond analytical tractability. Blinder (1997, p. 6) argues that '*academic macroeconomists tend to use quadratic loss functions for reason of mathematical convenience, without thinking much about their substantive implications. The assumption is not innocuous [...] I believe that practical central bankers and academics would benefit from more serious thinking about the functional form of the loss function*'. Describing his experience as Fed Vice-Chairman, Blinder (1998, pp. 19-20) pushes the argument even further and states that '*in most situations the central bank will take far more political heat when it tightens pre-emptively to avoid higher inflation than when it eases pre-emptively to avoid higher unemployment*'.

Cecchetti (2001, p. 49) also supports this view and reasons '*the [conventional] objective function is symmetrical, including only quadratic terms. The implication is that policy makers care equally about extreme positive and extreme negative events. This is surely not the case: we would expect policy makers to take action when the mean and variance of forecast distributions are likely to stay the same, while the probability of some extreme bad event increases*'.

The modeling of nonquadratic loss functions has been the goal of a promising avenue of research which has shown how alternative plausible formulations of the monetary objectives may also lead to tractable solutions of the central bank optimization problem (see Nobay and Peel, 1998, Cukierman, 2001, Orphanides and Wieland, 2000, and Ruge-Murcia, 2002). In particular, those contributions can be classified in two groups, each one corresponding to a different form of the objective function. We label the first group *symmetric nonquadratic* and the second group *asymmetric nonquadratic*.

Symmetric nonquadratic forms capture the idea that policy makers may suffer higher order losses than quadratic from large movements of the target variables. Indeed, even if the variance of the output process is unchanged, the information embodied in higher moments of the distribution may serve to move policy rates in the face of extreme events.

Alternatively, one may think of monetary authorities as weighting differently target variable deviations of the same magnitude but opposite sign. In particular, the above quotation from Blinder (1998) seems to suggest that the political pressures faced by the Fed not to engage expansionary measures during output contractions are stronger than those faced to tighten monetary policy during output expansions, thereby calling for an asymmetric behavior in output.

This paper derives the efficient monetary policy frontier using a nonparametric specification of the output gap argument into the loss function. In so doing, we discriminate analytically among (i) quadratic, (ii) symmetric nonquadratic and (iii) asymmetric nonquadratic preferences on the basis of the different predictions they do have on the form of the efficient policy frontier. Kernel regression estimates on US data spanning the period 1956:2 - 2001:1 shows that the preferences of the Fed are consistent only with a loss function which is both nonquadratic and asymmetric.

The paper is organized as follows. Section 2 sets up the model and shows how nonquadratic forms of the objective function translate into nonlinearities of the efficient policy frontier. Section 3 presents the estimates while the last section concludes.

2 The Model

2.1 The Economy

The supply side of the economy is characterized by an augmented Phillips curve[1]

$$y_t = \alpha (\pi_t - \pi^e) + u_t, \ \ \alpha > 0 \tag{1}$$

where y_t denotes the output gap measured as the difference between actual and potential output, π_t represents inflation and π^e stands for inflation expectations taken at the beginning of the period. The supply disturbance is denoted by u_t and under the assumption of rational expectations

$$\pi^e = E_{t-1}\pi_t$$

with E_{t-1} being the expectation conditional upon the information available at time $t-1$.

[1] See Lucas (1972) for a formal derivation of such an aggregate supply.

The central bank is assumed to affect inflation through a policy instrument, i_t, such that

$$\pi_t = f(i_t) \tag{2}$$

The $f(\cdot)$ is a monotonic, continuous and differentiable function and it reflects the usual assumption that monetary authorities choose, either directly or indirectly, the rate of inflation after observing the disturbances at time t (see Svensson 1997).

2.2 A General Specification of the Loss Function

The central bank sets policy rates in the face of the following intertemporal criterion

$$\underset{\{i_t\}}{Min} \ E_t \sum_{\tau=0}^{\infty} \delta^{\tau} L_{t+\tau} \tag{3}$$

where δ is the discount factor and L stands for the period loss function. Our framework differs from the conventional quadratic set up in that we employ a more general specification of the monetary authorities' objective function with respect to the output gap

$$L_t = \frac{1}{2}(\pi_t - \pi^*)^2 + \lambda g(y_t) \tag{4}$$

The λ is a positive coefficient representing policy makers' aversion towards output stabilization relative to price stability and the function $g(\cdot)$ possesses the following properties

$$\begin{aligned} g'(y_t) &< 0 \text{ for } y_t < 0, \ g'(y_t) \geq 0 \text{ for } y_t \geq 0 \\ g(0) &= g'(0) = 0 \text{ and } g''(y_t) > 0 \end{aligned}$$

The number of tags denotes the order of the partial derivatives.

The objective function (4) tends to its minimum whenever both inflation and output gaps shrink and larger losses are associated with larger absolute values of the gaps at an increasing rate. While the inflation argument reads the usual quadratic form, we adopt a nonparametric specification for the output gap penalty which accommodates a number of recent proposals. As argued by Cukierman and Muscatelli (2002), the third derivative of the function $g(\cdot)$ potentially introduces some non standard argument into the loss function and within our nonparametric set up it can be possible to distinguish among three classes of models:

i) *symmetric quadratic*, which corresponds to $g'''(y_t) = 0$ for any y_t;

ii) *symmetric nonquadratic*, which corresponds to $g'''(y_t) < 0$ for $y_t < 0$ and $g'''(y_t) \geq 0$ for $y_t \geq 0$ with $g'''(y_t)_{|y_t<0} = g'''(y_t)_{|y_t>0}$ in absolute value for any y_t;

iii) *asymmetric nonquadratic*, which corresponds to $g'''(y_t) <$ or $= 0$ for any y_t.

The first case writes a conventional quadratic form according to which only the size of deviations matter. Under the second scenario, $g(\cdot)$ is still symmetric around zero but, unlike the quadratic, the change in the marginal loss that a further positive deviation brings about is a positive function of output gap over its domain, i.e. the second derivative is non constant. By contrast, in the face of asymmetric nonquadratic preferences not only the change in the marginal loss is a positive function of y_t but also the marginal loss evaluated at a given negative output gap is larger than the marginal loss evaluated at a positive deviation of the same magnitude. This implies that monetary authorities are more concerned about undershooting potential output rather than overshooting it.

2.3 The Optimal Policy

We let monetary authorities choose policy rates in a discretionary fashion after the public have formed their expectation. Indeed, the case for an optimal monetary policy without commitment seems to be closer to the actual practice of the Fed which rarely tie their hands over the course of future policy actions. Because no endogenous state variable enters the model, the intertemporal policy problem reduces to a sequence of static optimization problems.

Differentiating the loss function (4) with respect to i_t subject to equations (1) and (2) yields the following first order condition

$$(\pi_t - \pi^*)\frac{\partial \pi_t}{\partial i_t} + \lambda g'(y_t)\frac{\partial y_t}{\partial \pi_t}\frac{\partial \pi_t}{\partial i_t} = 0 \tag{5}$$

with $\frac{\partial y_t}{\partial \pi_t} > 0$ and $\frac{\partial \pi_t}{\partial i_t} \neq 0$. Since the objective function is globally convex, and the relation between policy instrument and ex-post inflation is monotonic through the function $f(\cdot)$, there exists a unique value of π_t which satisfies (5). Computing partial derivatives and simplifying terms, the optimality condition reads

$$(\pi_t - \pi^*) = -\lambda\alpha g'(y_t)$$

Applying the implicit function theorem, it is possible to write

$$\frac{\partial \pi_t}{\partial y_t} = -\lambda\alpha g''(y_t) \tag{6}$$

The latter expression is negative for all three classes of models since the second partial derivatives are always positive. While this implies the existence of a trade-off between output and inflation stabilization, it does not allow to discriminate among alternative functional forms of policy makers' loss function as the third derivative does not show up in the equation. Then, to the extent that the optimal monetary policy is nonlinear, we partially differentiate (6) with respect to the output gap

$$\frac{\partial^2 \pi_t}{\partial (y_t)^2} = -\lambda \alpha g''' (y_t) \tag{7}$$

Interestingly, under the symmetric quadratic case the latter expression is zero reflecting the notion of a linear efficient policy frontier. By contrast, symmetric nonquadratic preferences imply that equation (7) is positive for $y_t < 0$ and non positive for $y_t \geq 0$ with the change in marginal inflation taking the same value for positive and negative output gaps of the same magnitude. Lastly, only an asymmetric objective justifies a positive expression over the entire domain of y_t.

The optimizing device embodied in (7) is attractive in that it allows us to reversely engineer the functional form of monetary authorities' objectives, which is unobservable, from the observed correlation between inflation and output. In fact, we attempt to discriminate among the three competing classes of loss functions through the evidence drawn upon the form of the efficient policy frontier.

3 Empirical Results

We perform a nonparametric local linear kernel regression on output gap to estimate the first partial derivative of the inflation conditional mean with respect to output gap. The analysis is conducted on US quarterly seasonally adjusted data spanning the period 1956:2-2001:1. Inflation has been extracted from the web site of the Federal Reserve Bank of St. Louis and it has been constructed from the (log) GDP chain-weighted price index. Output gap has been obtained from the Congressional Budget Office. We use a second order Gaussian kernel and the likelihood cross validation procedure to obtain a value for the fixed bandwidth parameter, which serves to determine the window of observations for the point estimates. The motivations underlying this method can be found in Pagan and Ullah (1999), though the results are unaffected by using the least squares cross validation criterion and an higher-order kernel.

Figure 1 plots the estimated first partial derivative of the inflation conditional mean with respect to output gap as a function of output gap. The key element in the graph is the slope which thus reads the second partial derivative and, according to the condition (7), is informative about the sign of $g''' (\cdot)$. The latter is crucial because it allows to uncover the form of policy makers' loss function through the simple model of the previous section. The levels of the estimated partial derivative have the negative sign predicted by equation (6) while the pattern depicted in Figure 1 is positive and significant over most sample consistently with a negative value of $g'''(\cdot)$ over the entire domain. Moreover, deviations of the same magnitude but opposite sign are treated differently as negative output gaps involves larger marginal movements of policy rates. Interestingly, this finding supports the notion of an *asymmetric nonquadratic* loss function while it rejects the hypothesis that the preferences of the Fed have been historically either quadratic or symmetric nonquadratic.

4 Conclusions

This paper develops a method to uncover central banker's loss function from the estimation of a nonparametric efficient policy frontier. Using a kernel regression on US data, we find that the form of the Fed policy preferences towards output stabilization has been historically nonquadratic and asymmetric. While this finding suggests some caution about using quadratic loss function for policy evaluations, it also suggests that the US efficient policy frontier has been nonlinear since at the margin output contractions of a given amount have brought about a more vigorous policy response than output expansions of the same magnitude.

References

Blinder, A., 1997, Distinguished Lecture on Economics and Government: What Central Bankers Could Learn from Academics and Viceversa, Journal of Economic Perspective 11, 3-19.

Blinder, A., 1998, Central Banking in Theory and Practice, (Mit Press).

Cecchetti, S.G., 2001, Making Monetary Policy: Objectives and Rules, Oxford Review of Economic Policy 16, 43-59.

Cukierman, A., 2001, The Inflation Bias Result Revisited, mimeo, Tel-Aviv University.

Cukierman, A, and V.A. Muscatelli, 2002, Do Central Banks have Precautionary Demands for Expansions and for Price Stability? - Theory and Evidence, mimeo, Tel-Aviv University.

Lucas, R., 1972, Expectations and the Neutrality of Money, Journal of Economic Theory 4, 103-124.

Nobay, R. and D. Peel, 1998, Optimal Monetary Policy in a Model of Asymmetric Central Bank Preferences, mimeo, London School of Economics.

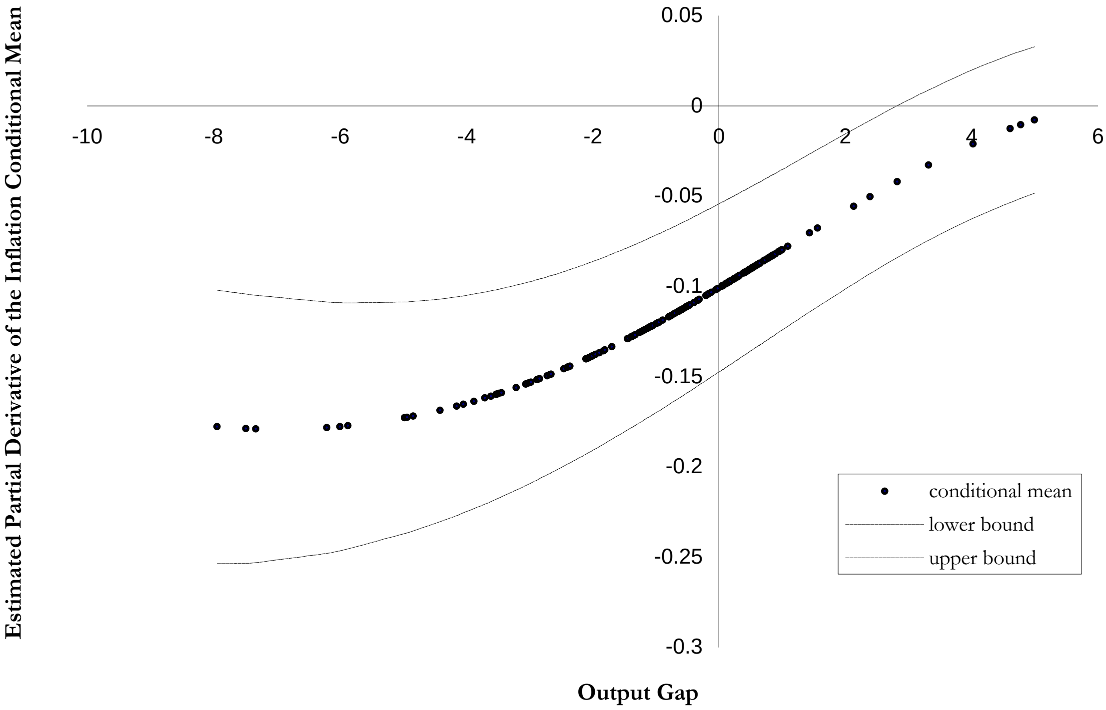
Orphanides, A. and V. Wieland, 2000, Inflation Zone Targeting, European Economic Review 44, 1351-1387.

Pagan, A. and A. Ullah, 1999, Nonparametric Econometrics, (Cambridge University Press).

Ruge-Murcia, F.J., 2002, The Inflation Bias when the Central Banker Targets the Natural Rate of Unemployment, European Economic Review, forthcoming.

Svensson, L.E.O., 1997, Optimal Inflation Targets, Conservative Central Banks, and Linear Inflation Contracts, American Economic Review 87, 98-114.

Figure 1: Nonparametric Evidence of Central Banker's Loss Function



The estimates of the first partial derivative of the inflation conditional mean with respect to the output gap are obtained from a nonparametric local linear kernel regression of inflation on output gap using US data over the period 1956:2 - 2001:1. A second order Gaussian kernel and the likelihood cross validation procedure are used to get a value for the fixed bandwith parameter. Dashed lines represent standard errors.